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Validation of the Armed Services Vocational Aptitude Battery (ASVAB) Selector Composites: Radioman (RM) Class "A" School

Janet Held

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13. ABSTRACT (Maximum 200 words)

This study validated Armed Services Vocational Aptitude Battery (ASVAB) selector composites against school performance measures for the Navy Radioman (RM) rating. The ASVAB consists of the following 10 tests: General Science (GS), Arithmetic Reasoning (AR), Word Knowledge (WK), Paragraph Comprehension (PC), Numerical Operations (NO), Coding Speed (CS), Auto and Shop Information (AS), Mathematics Knowledge (MK), Mechanical Comprehension (MC), and Electronics Information (EI).

The purpose of this study was to determine whether an alternative ASVAB composite is more valid in predicting RM Class "A" school performance than the current operational composite, VE+NO+CS. Concern over high attrition was the basis for this study. Results indicate that the composite VE+MK+CS is a suitable replacement. The RM rating is one of seven ratings that comprise the Operations Control Navy occupational group. In an effort to consolidate and reduce the number of Navy operational composites, the VE+MK+CS composite recommended for the RM rating will be assessed for the remaining six ratings of the Operations Control group.

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Foreword

This study was conducted in response to a request from the Bureau of Naval Personnel (PERS-23) to validate the Armed Services Vocational Aptitude Battery (ASVAB) selection criteria for the Radioman (RM) Class "A" school. Concerns of high attrition prompted the request.

This effort was sponsored by PERS-24 and funded by program element 090000N, work unit WRB1008. Results are intended for use by BUPERS, RM personnel, and the research community.

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Captain, U.S. Navy   Technical Director (Acting)
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Summary

Problem

This validation study of Armed Services Vocational Aptitude Battery (ASVAB) selector composites for the Radioman (RM) Class "A" school was conducted in response to a request from the Bureau of Naval Personnel (PERS-23). Concerns over high attrition prompted the request. The RM rating is one of seven ratings comprising the Operations Control (OA) occupational group. Consistent with the Navy's consolidation efforts, selector composites recommended for RM will be evaluated for the OA group.

Objectives

The objectives of this research were to (1) validate the operational ASVAB composite against RM school performance measures, (2) identify and evaluate alternative ASVAB composites that would be more effective for determining qualification for school assignment, and (3) determine a minimum qualifying for the recommended selector composite that would reduce RM "A" school attrition.

Approach

The RM sample was randomly divided into a test selection sample and a hold-out sample. A multiple regression procedure was used for two methods to identify the most valid test composite in the test selection sample. The experimental composite and operational selector composite were validated in the hold-out sample. Method I did not correct for restriction in range of the test scores, while Method II did. Results from the hold-out sample validation were used to compare the experimental and operational selector composite. When replacing the operational composite was warranted (assessed from increase in validity or expected improvement in the graduation rate) an existing Navy operational selector composite most similar to the experimental composite was evaluated as a candidate replacement.

Minimum qualifying scores for a recommended composite were evaluated on the basis of (1) attrition rate, (2) waiver rate, (3) yearly input requirement, (4) percent of the recruit population qualifying for school selection, and (5) the number of school graduates who would have been disqualified from school selection.

Results and Conclusions

Methods I and II identified the same experimental composite, MK+CS+AR+VE. The experimental composite had higher validity than the operational selector, VE+NO+CS. Of three Navy operational composites considered as candidate replacements, the Business/Clerical composite, VE+MK+CS, had the highest validity.

Recommendations

The following recommendations are addressed to PERS-23:

1. The VE+MK+CS composite is recommended to replace the operational selector composite, VE+NO+CS, for the RM "A" school. The recommended minimum qualifying score for VE+MK+CS is 147.

2. The VE+MK+CS composite should be considered in the validation study that will be conducted for the remaining ratings of the OA occupational group.

Adopting these recommendations should reduce attrition for the RM "A" school and could result in a reduction in the number of ASVAB operational selector composites used by the OA occupational group.

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Introduction

Background and Problem

Concerns over high attrition of Radioman (RM) Class "A" school students prompted a request by the Bureau of Naval Personnel (PERS-23) for validation of the Armed Services Vocational Aptitude Battery (ASVAB) selection criteria.

The ASVAB has been the personnel selection and classification instrument for all the military services since 1976. The ASVAB consists of the following ten tests: General Science (GS), Arithmetic Reasoning (AR), Word Knowledge (WK), Paragraph Comprehension (PC), Numerical Operations (NO), Coding Speed (CS), Auto and Shop Information (AS), Mathematics Knowledge (MK), Mechanical Comprehension (MC), and Electronics Information (EI). These tests, described briefly in Table 1, are used in various combinations of composites to select military recruits into occupational specialties. Table 2 lists the 11 ASVAB operational selector composites used by the Navy.

The RM rating is one of seven ratings comprising the Operations Control (OA) occupational group, which is 1 of 14 Navy occupational groups. While the current study is concerned with identifying the most valid ASVAB selector composite for a specific rating, any composite chosen should be viewed as a candidate for replacing the operational selector composites of all the OA group ratings. There are currently three operational selector composites for the seven ratings of this group: (1) General Technical VE+AR, (2) Basic Electricity and Electronics AR+2MK+GS, and (3) Clerical VE+NO+CS (see Table 1 for a description of the tests). The RM school is the only OA group rating using the Clerical composite. This composite is used for only a few other Navy ratings and is in the process of being replaced by the Business/Clerical composite VE+MK+CS. VE+MK+CS is used in the Student Testing Program for high school students and will be evaluated in this study.

Objectives

The objectives of this research were to (1) validate the operational ASVAB composites against RM school performance measures, (2) identify and evaluate alternative ASVAB composites that would be more effective for determining qualification for "A" school assignment, and (3) determine a minimum qualifying for the recommended selector composite that would reduce RM "A" school attrition.

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Table 1

Content of ASVAB Tests

Test	Abbreviation	Description
General Science	GS	A 25-item test of knowledge of the physical (13 items) and biological (12 items) sciences--11 minutes.
Arithmetic Reasoning	AR	A 30-item test of ability to solve arithmetic word problems--36 minutes.
Word Knowledge[a]	WK	A 35-item test of knowledge of vocabulary, using words embedded in sentences (11 items) and synonyms (24 items)--11 minutes.
Paragraph Comprehension[a]	PC	A 15-item test of reading comprehension--13 minutes.
Numerical Operations	NO	A 50-item speed test of ability to add, subtract, multiply, and divide one- and two-digit numbers--3 minutes.
Coding Speed	CS	An 84-item speed test of ability to recognize numbers associated with words from a table--7 minutes.
Auto and Shop Information	AS	A 25-item test of knowledge of automobiles, shop practices, and use of tools--11 minutes.
Mathematics Knowledge	MK	A 25-item test of knowledge of algebra, geometry, fractions, decimals, and exponents--24 minutes.
Mechanical Comprehension	MC	A 25-item test of knowledge of mechanical and physical principles--19 minutes.
Electronics Information	EI	A 20-item test of knowledge of electronics, radio and electrical principles and information--9 minutes

[a]Verbal score: VE = WK + PC (raw scores).

Table 2

Navy Operational ASVAB Selector Composites

Composite	Components
General Technical	VE+AR
Mechanical	VE+MC+AS
Electronics	AR+MK+EI+GS
Clerical	VE+NO+CS
Basic Electricity & Electronics	AR+2MK+GS
Engineering	MK+AS
Cryptologic Technician	VE+AR+NO+CS
Hospitalman	VE+MK+GS
Machinery Repairman	AR+MC+AS
Submarine	VE+AR+MC
Business/Clerical[a]	VE+MK+CS

Note. See Table 1 for complete test names.
[a]Student Testing Program composite implemented June 1987.

Approach

Predictors

The predictors used in this study were the 10 tests of ASVAB Forms 8 through 14, described briefly in Table 1. Standardized scores were used for all analyses.

Criterion

The criterion was final school grade (FSG) provided by the RM "A" school. These grades were the average of 12 weekly progress tests. Although FSG is scaled from 0 to 100, passing scores are usually between 70 and 100. A mathematical procedure developed by Abrahams and Alf (1992) estimated attrite FSGs. The method is detailed in Appendix A.

Samples

The RM sample size was 2,990. There were 2,511 graduates, 318 academic attrites, and 161 nonacademic attrites. Data collection was from January 1986 through March 1987.

Data Analyses

RM students were randomly assigned to a test selection sample (60% of the students) and a hold-out sample (40% of the students). Prior to this assignment, subjects were sorted into graduates, academic attrites, and nonacademic attrites to ensure equal percentages were present in both samples, as shown in Table 3.

Table 3

Percentage of Academic and Nonacademic Attrites in the Test Selection and Hold-out Samples

School	Test Selection Sample (N = 1,795)			Hold-out Sample (N = 1,195)		
	Academic	Nonacademic	Combined	Academic	Nonacademic	Combined
RM	.11	.05	.16	.11	.05	.16

Two methods were used with the test selection sample in determining the most predictive ASVAB composite. In both methods, a forward stepwise multiple regression procedure selected the ASVAB test most highly correlated with FSG into a prediction equation followed by tests that provided the largest increase in the multiple correlation.[1] The first four tests to enter the equation were designated as the experimental composite. Method I did not correct for restriction in range of the ASVAB test scores, while Method II did. The multivariate correction procedure for Method II is explained in Appendix B (Lawley, 1943).

The most predictive composites identified by the two methods and the operational composite were then cross-validated in the hold-out sample. Composite scores (used to correlate with FSG) were calculated by summing standardized test scores. This procedure unit weights each test. Unit weights were used because they add stability and can be generalized to future samples more successfully than the exact weights determined from regression analyses, which are sample specific.

Composite validities were compared after correcting for restriction in range. Replacing the operational selector composite was recommended when the experimental composite demonstrated (1) a .05 increase in validity or (2) a 2-percent improvement in the graduation rate.[2]

When replacing an operational selector composite was warranted, existing Navy operational composites (Table 2) most similar to the experimental composite were evaluated as candidate replacements. The choice is limited to Navy composites because, over the course of numerous validation studies, implementing statistically derived composites would result in an unmanageable

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[1]For the multiple regression, WK and PC were combined into the ASVAB Verbal (VE) composite.

[2]The Taylor Russell tables (1939) were used to translate gain in validity into expected gain in the graduation rate.

number of highly correlated operational selector composites, which does not improve classification efficiency.

Finally, minimum qualifying scores were evaluated for the candidate replacement. Expectancy tables using school data are developed for an adequate operational composite, while theory-based tables (Taylor & Russell, 1939) are developed for replacements. (A replacement composite cannot be adequately evaluated for a sample selected by the operational composite; because the composite is analyzed as a second screen, improvements in graduation rates may be inflated.) Factors considered in recommending the minimum qualifying score were (1) attrition rate, (2) waiver rate, (3) yearly school input requirement, (4) percentage of the recruit population qualifying for school selection, and (5) number of school graduates who would have been disqualified from school selection.

Results and Conclusions

Experimental Selector Composites

Both Methods I and II identified MK+CS+AR+VE as the experimental selector composite for the RM test selection sample. Appendix C gives the summary statistics for the regression analyses. Table 4 lists the uncorrected and corrected validities for MK+CS+AR+VE and the operational selector composite, VE+NO+CS, for the RM hold-out sample.

Table 4

Operational and Experimental Composite Cross-validities
for the RM Hold-out Sample

Operational and Experimental Composites	Cross-validities	
	r_u	r_c
VE+NO+CS (Operational)	.29	.47
MK+CS+AR+VE (Experimental-Methods I & II)	.43	.55

Notes.

1. See Table 1 for complete test names.
2. Both r_u and r_c (validities uncorrected and corrected for restriction in range, respectively), are Pearson product-moment correlations.
3. The correction procedure used to determine r_c estimates composite validities for an unrestricted population (i.e., for a typical applicant group). It should not be confused with the correction procedure that permits unbiased selection of tests into a regression equation. Guilford (1965) gives the formula for r_c (pp. 340-345). Case I was used for the operational selector composite; Case III, for the experimental composite.

Comparing corrected validities, the validity of .55 for MK+CS+AR+VE was .08 higher than the validity of .47 for the operational selector composite, VE+NO+CS. This increase in validity was sufficient to warrant examination of candidate replacement composites.

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Candidate Composite Selection and Evaluation

From Table 2, which lists the Navy operational selector composites, Cryptologic Technician, VE+AR+NO+CS, and Business/Clerical, VE+MK+CS, were evaluated as candidate replacement composites because each contained three of the four tests of the experimental composite, MK+CS+AR+VE. In addition, the Basic Electricity & Electronics composite, AR+2MK+GS, was considered as a candidate replacement because (1) the MK regression weight for the experimental composite for both methods I and II was more than twice that of the other tests and (2) it is the operational selector for two of the OA group ratings. Table 5 lists the uncorrected and corrected validities for these candidate replacement selector composites for the RM hold-out sample.

Table 5

Candidate Composite Cross-validities for the RM Hold-out Sample

Candidate Composites	Cross-validities	
	r_u	r_c
VE+AR+NO+CS	.37	.51
AR+2MK+GS	.40	.51
VE+MK+CS	.40	.53

Note. See Table 1 for complete test names.

Comparing corrected validities for the three candidate composites, .53 for VE+MK+CS was highest. This validity was .06 higher than the .47 validity for the operational selector composite, VE+NO+CS, which is sufficient to propose that VE+MK+CS replace VE+NO+CS for use in RM "A" school selection.

Minimum Qualifying Scores

Minimum qualifying scores for the proposed operational selector composite, VE+MK+CS, were evaluated with expectancy tables derived from the Taylor Russell tables (1939). The expectancy analysis, given in Appendix D, showed VE+MK+CS=144 was equivalent to VE+NO+CS=141 (the RM operational composite with minimum qualifying score) in that they both qualified 85 percent of the recruit population (FY86, N=89,816) for school selection. However, a 1-percent improvement in the graduation rate was expected using VE+MK+CS=144 (85% - 84%). Raising the VE+MK+CS minimum qualifying score to 147 further improved the expected graduation rate by 2 percent (to 87%).

Recommendations

The following recommendations are addressed to PERS-23:

1. The VE+MK+CS composite is recommended to replace the operational selector composite, VE+NO+CS, for the RM "A" school. The recommended minimum qualifying score for VE+MK+CS is 147.

2. The VE+MK+CS composite should be considered in the validation study that will be conducted for the remaining ratings of the OA occupational group.

Adopting these recommendations should reduce attrition for the RM "A" school and could result in a reduction in the number of ASVAB operational selector composites used by the OA occupational group.

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[3]Cited in Appendix C.

Appendix A

Scoring of Failures

Scoring of Failures

The scoring of failures procedure is based on the assumption that, for a population of Navy applicants, the combined distribution of final school grades (FSGs) for graduates and attrites is normal. On the basis of the mathematical properties of a normal curve, a mean FSG for attrites can be calculated at the appropriate lower point of the FSG distribution. For the case where academic attrites score significantly lower than nonacademic attrites on the operational selector composite (as was the case for RM), each attrite category is assigned a different mean FSG. Required values and formulas for computing the two means follow.

P_1 = the proportion of academic attrites.

P_2 = the proportion of nonacademic attrites.

P_3 = the proportion of graduates.

$\overline{X}_g$ = the mean final school grade for graduates.

SD_g = the standard deviation of final school grades for graduates.

z_1 = the z-score (standard score) below which the proportion p_1 falls.

z_2 = the z-score (standard score) below which the combined proportions p_1 and p_2 fall.

y_1 = the height of the normal curve at z_1.

y_2 = the height of the normal curve at z_2.

Step 1

The mean for academic attrites, $\overline{X}_a$, can be determined as follows:

$\overline{X}_a = \overline{X}_g - A(SD_g)$, where

$$A = \frac{\left[\dfrac{y_2}{p_3} + \dfrac{y_1}{p_1} \right]}{\sqrt{1 + \dfrac{z_2 y_2}{p_3} - \left(\dfrac{y_2}{p_3} \right)^2}} .$$

The mean for nonacademic attrites, $\overline{X}_{na}$, can be determined as follows:

$\overline{X}_{na} = \overline{X}_g - A(SD_g)$, where

$$A = \frac{\left[\dfrac{y_2}{p_3} + \dfrac{y_2 - y_1}{p_1} \right]}{\sqrt{1 + \dfrac{z_2 y_2}{p_3} - \left(\dfrac{y_2}{p_3} \right)^2}} .$$

Step 2

Assign the estimated mean criterion scores, $\overline{X}_a$ and $\overline{X}_{na}$, determined in step 1, to the academic and nonacademic attrites, respectively.

Step 3

Compute the correlation between each predictor and the criterion for the combined distribution of graduates, academic attrites, and nonacademic attrites.

Step 4

Correct the correlations from step 3 for coarse grouping (assigning a mean criterion score to every attrite reduces variance and, therefore, the correlation coefficient). The formulas used for this correction are:

$r_c = r_{xy}/SDz'$, where

$$SDz' = \sqrt{1 - (p_1 s^2_a)) - (p_2 s^2_{na})} \quad ,$$

s^2_a, the variance of the academic attrite segment =

$$1 - \frac{z_1 y_1}{p_1} - \left(\frac{y_1}{p_1}\right)^2 \quad ,$$

and s^2_{na}, the variance of the nonacademic attrite segment =

$$1 + \left[\frac{z_1 y_1 - z_2 y_2}{p_2}\right] - \left[\frac{y_1 - y_2}{p_2}\right]^2 .$$

Appendix B

Correction Procedure Used in Method II

Correction Procedure Used in Method II

In order for the regression analysis used to derive the ASVAB composite most predictive of final school grade (FSG) not to be biased against tests used for school selection, test scores must be corrected for restriction in range. This is accomplished in Method II by using a Navy applicant population ASVAB/FSG intercorrelation matrix where correlations between ASVAB tests and FSG are estimated using multivariate correction formulas (Lawley, 1943).

The next page gives two intercorrelation matrices (including means and standard deviations) required for the multivariate correction procedure. The first is the ASVAB/FSG intercorrelation matrix for the RM test selection sample (see Table 1 for the full test names). The second is an ASVAB intercorrelation matrix for a Navy applicant population. At the bottom of the page are the estimated population correlations between ASVAB tests and FSG.

RM Test Selection Sample Intercorrelations
with Means and Standard Deviations

	GS	AR	NO	CS	AS	MK	MC	EI	VE	FSG	Mean	SD
GS	1.000	.358	-.108	.034	.400	.386	.474	.494	.668	.127	47.53	7.34
AR		1.000	.212	.181	.252	.587	.428	.310	.306	.266	48.00	6.90
NO			1.000	.299	-.131	.221	-.057	-.108	-.180	.110	56.12	5.59
CS				1.000	-.066	.202	.065	.047	.039	.199	54.73	6.57
AS					1.000	.133	.521	.518	.342	.050	46.25	7.61
MK						1.000	.391	.280	.344	.319	47.98	6.81
MC							1.000	.507	.418	.171	46.32	7.46
EI								1.000	.463	.071	47.06	7.30
VE									1.000	.160	49.28	5.72
FSG										1.000	90.25	5.18

Population (Applicant FY86) Intercorrelations
with Means and Standard Deviations

	GS	AR	NO	CS	AS	MK	MC	EI	VE	Mean	SD
GS	1.000	.601	.234	.223	.505	.591	.635	.666	.773	52.30	8.28
AR		1.000	.464	.377	.409	.740	.630	.528	.626	51.46	8.22
NO			1.000	.616	.027	.460	.218	.139	.314	51.74	8.26
CS				1.000	.039	.365	.212	.152	.331	53.13	7.86
AS					1.000	.269	.636	.658	.437	52.99	9.14
MK						1.000	.558	.476	.551	50.64	8.71
MC							1.000	.661	.582	51.98	8.88
EI								1.000	.593	53.25	8.67
VE									1.000	52.17	7.06

Correlations (Validities) for Population from Multivariate
Correction Program and above Matrices

	GS	AR	NO	CS	AS	MK	MC	EI	VE
FSG	.276	.401	.300	.319	.131	.430	.290	.198	.324

Appendix C

Multiple Regression for Methods I and II

Multiple Regression for Methods I and II

RM Test Selection Sample
Method I (MK+CS+AR+VE)

TEST	STEP	MULTR	RSQ	F	FSIG	RSQCH	FCH	SIGCH	REG-DF	RES-DF
MK	1	.3188	.1016	202.875	.000	.1016	202.875	.000	1	1793
CS	2	.3470	.1204	122.673	.000	.0188	38.255	.000	2	1792
AR	3	.3577	.1280	87.600	.000	.0075	15.472	.000	3	1791
VE	4	.3606	.1301	66.903	.000	.0021	4.325	.038	4	1790

Recruit Applicant Population (FY86)
Method II (MK+CS+AR+VE)

TEST	STEP	MULTR	RSQ	RSQCH
MK	1	.4300	.1849	.1849
CS	2	.4639	.2152	.0303
AR	3	.4734	.2241	.0090
VE	4	.4756	.2262	.0021

The multiple regression results (SPSS[x], 1983) for Method I show that CS is entered into the composite equation at Step 2, at which point the multiple correlation for the composite MK+CS is .3470. The squared multiple correlation (the proportion of final school grade (FSG) variance accounted for by the composite) is .1204. The F statistic to determine the significance of the predictive relationship between the composite MK+CS and FSG is 122.673. The probability that this predictive relationship is due to chance is less than .001. The change in the squared multiple correlation upon entering the CS test into the equation is .0188. The F statistic for change (to determine the significance of the increase in the predictive relationship by adding CS) is 38.255, while the probability that the significance of this addition is due to chance is less than .001. The regression and residual degrees of freedom are 2 and 1792, respectively.

Method II is based on corrected correlations. Since there are no appropriate significance tests for corrected correlations, the F tests for this method do not apply.

Appendix D

Evaluation of Proposed Composite Minimum Qualifying Scores for the RM "A" School

Evaluation of Proposed Composite Minimum Qualifying Scores for the RM "A" School

The Taylor Russell tables (1939) are used to predict improvement in the percentage of personnel performing satisfactorily that would result from use of a more valid selection instrument. The tables, derived for this appendix, use the following information: (1) the selection ratio, which is the proportion of the applicant population to be hired (for Navy use, it is the percentage of recruits qualified for school selection at a specified minimum qualifying score), (2) validity of the selection instrument (ASVAB selector composite), and (3) base rate, which is the success rate without having used a selection instrument (unknown for the Navy but determined by the first two variables and the known school graduation rate).

Evaluation of Proposed Composite Minimum Qualifying Scores for the RM "A" School

| Selection Ratio | Selector Composite Minimum Qualifying Scores | | Percent Expected to Graduate | | Percent Improvement |
	Operational (VE+NO+CS)	Proposed (VE+MK+CS)	Current $r_c = .47$	Proposed $r_c = .53$	
.90	141	137	83	84	1
.85	144[a]	141	84	85	1
.80	147	144	85	86	1
.75	149	147[b]	86	87	1
.70	152	149	87	88	1

Note. The validity of a composite, r_c, is a Pearson product-moment correlation corrected for restriction in range of test scores.

[a] Current minimum qualifying score for the operational composite (144).

[b] Recommended minimum qualifying score for the proposed composite (147).

The expected improvement rates are based upon the performance of the current sample. These rates may differ for students selected in the future depending upon the extent to which differences occur in (1) ability distributions and motivation and (2) conditions for selection (recruit population ability distribution, quota requirements, etc.).

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